Pit and fissure sealants: current evidence and concepts

By Professor Laurence J. Walsh

When used as a primary preventive measure, pit and fissure sealants have been used widely and successfully to prevent pit and fissure caries for more than 20 years. In the past decade, the cost-effectiveness of pit and fissure sealants has been studied mostly in school-based programs involving children with high caries risk from low socio-economic backgrounds. Sealant programs are worthwhile and cost-effective for primary prevention of pit and fissure caries in these high risk children, and their use helps to reduce the oral health disparities of children from differing backgrounds.

Figure 1. Occlusal surfaces of the maxillary (A&B) and mandibular molars (C&D) in the one patient. Moisture contamination of the lingual aspect (asterisk in D) has led to caries occurring beneath one of the two sealants (D). The maxillary molars have stained fissures but no caries.

Resin sealants

A recent Cochrane meta-analysis of the effectiveness of sealants published in 2004 collated data from eight clinical trials, of which seven were split-mouth studies and one a parallel-group study. The overall effectiveness of resin-based sealants in preventing dental decay on first permanent molars was high, with reductions in caries from 86% at 12 months to 57% at 48-54 months.[1,2]

Complete loss of a resin sealant does not afford any protection, however it does not appear to predispose that surface to caries any more than its contralateral paired surface. However, a partial loss of sealant because of abrasive wear that results in the exposure of the terminal ends of a fissure is a potential failure in that it creates an environment conducive to caries. Moisture contamination of mandibular molar lingual surfaces during sealant placement is a particular hazard. Even the apparently well-applied sealant does not necessarily constitute permanent obturation of pits and fissures.[3] Periodic clinical observation is necessary to determine the success or potential failure of the sealant treatment.

The presence of an intact resin or glass ionomer sealant provides complete immunity to occlusal caries. It is well established that fissure regions beneath intact sealants become sterile and that incipient carious lesions beneath intact sealants do not progress with time. Techniques with direct and potent antibacterial actions such as photothermal lasers and ozone have been used successfully in conjunction with sealant therapy, with the former having the advantage of also providing an effective etching action if the appropriate laser wavelengths and parameters are used.[4-6]

The ability of resin sealants to prevent caries on the occlusal surfaces depends on the timing of application and the integrity of the sealant during retention. Moisture control is a major concern with resin-based materials. Lingual aspects of occlusal grooves in mandibular molars are a particular at-risk surface for saliva contamination (Figure 1). Similarly, molars that are sealed with the operculum covering the distal marginal ridge of the occlusal surface have twice the probability for retreatment as teeth not treated until the entire marginal ridge was exposed.[7]

GIC materials

In contrast to ionically inert resin-based sealants, glass ionomer cement materials when used as sealants can interact with enamel and release calcium, strontium and fluoride ions, which may have cariostatic actions and reduce the likelihood of primary caries development on a sealed surface. A range of viscous aesthetic conventional glass ionomer cements (GICs) have been developed specifically for use in fissure sealing or fissure protection. Using the finger-press method, these newer GICs appear to penetrate adequately and seal occlusal fissures in permanent molar teeth. Clinical studies of GIC materials such as Fuji IX used as sealants over three years have found sealant retention (full and partial) to be approximately 70%, with fissure caries approximately 0-4%.[8] When used as a sealant material on surfaces diagnosed as early enamel lesions in high caries risk children using the 'press-finger' technique, Fuji IX has shown excellent results even under

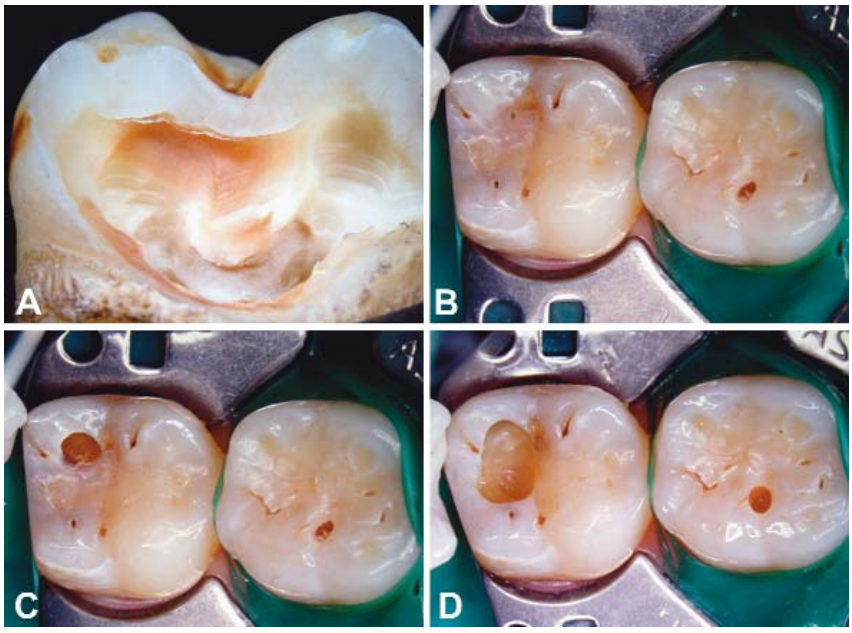

Figure 2. Clinical example of occult caries in mandibular second molars. A pinhole entry point is barely evident (B), but when opened up, caries undermining the occlusal surface can be seen clearly (C). The final preparation (D) is very similar to the outlines of the lesion shown in cross section on this extracted tooth (A).

Figure 3. DIAGNOdent unit from KaVo.

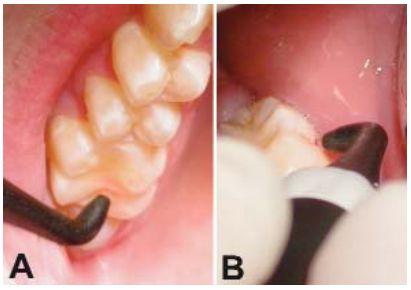

Figure 4. Examining pits and fissures with the conical A tip.

challenging clinical operating conditions. In a study conducted by Jo Frencken in Zimbabwe, the mean survival rate at 3 years was 71.4%, with the sealed surfaces showing immunity to further caries - some 96.3% of the treated surfaces survived 3 years without developing caries, despite in some cases partial loss of the material.[9] It is anticipated that the beneficial effects of GIC on enamel will over time see it being used more frequently for both protecting partially erupted tooth surfaces and for sealing erupted occlusal surfaces using low viscosity GIC materials such as Fuji IX and Triage.

Targeting patients and sites

Long term studies in which resin sealants once placed were not repaired have demonstrated caries reductions in first permanent molars ranging from 18 to 100 per cent.[10] It is important to realise that these trials were single application ones. In clinical practice, with a regular recall system, re-application may be readily undertaken. With only a single application, effectiveness over time declines significantly.

Sealing all pits and fissures as the teeth erupt for the whole population of children as a primary preventive measure has not been supported by large scale studies in which cost-benefit analyses were performed. Recent studies have estimated that 15 sealed first permanent molars or 10 sealed second permanent molars are necessary to prevent placement of one occlusal restoration,[11] thus sealants are more effective when placed in patients with risk factors for occlusal caries.

The use of sealants as a primary preventive measure is however clearly justified under certain conditions including:

1. Teeth considered to be at special risk of becoming carious, e.g. in caries-prone individuals, in teeth contralateral to those that have already become carious, and in teeth that have habitually plaque-covered fissured surfaces. In this context, it is important to realize that fissure caries may occur in teeth which have developed in the presence of optimal systemic fluoride.
2. For patients whose dental and/or general health is compromised by circumstances which render them especially at risk for dental caries.

Screening occlusal surfaces for caries

Because it is often difficult to assess accurately the status of small pit and fissure lesions using conventional examination methods, it is inevitable that monitoring them over time is fraught with danger. It is therefore inappropriate to adopt a watch-and-wait approach.

Careful observation of decalcification at the fissure openings (on dried, cleaned occlusal surfaces) has also been shown by Lynch and others to offer acceptable sensitivity for incipient lesions. A recent study by Fracaro and colleagues at the University of Queensland[12] disproved the commonly held notion of "fluoride bombs", i.e. occult lesions being due to fluoride exposure. This prospective, cross-sectional study examined the sensitivity and specificity of clinical assessment compared to bitewing radiographs in the detection of occlusal dentine caries in permanent molars. A total of 481 children aged 5-12 years from a school-based dental clinic were examined clinically, with the occlusal surfaces of 1929 sealed and unsealed (but unrestored) first and second permanent molars scored using specific criteria (Figure 2). Bitewing radiographs were assessed for dentin radiolucencies beneath the occlusal surface and correlated to the results of the clinical examinations, with particular attention paid to the patient's history, including systemic fluoride exposure. Of the 1833 teeth scored as clinically sound in the study, only 72 (4%) demonstrated a dentine radiolucency on bitewings. The sensitivity of the clinical examination for detecting such lesions was 0.96 and the specificity 0.58. Importantly, past fluoride exposure, in the forms of toothpaste use, or water fluoridation, did not affect the likelihood of dentine radiolucencies in bitewing radiographs beneath clinically sound occlusal surfaces. On this basis, the term "fluoride bomb" should be dropped from the lexicon of dental slang.

Use of laser fluorescence (DIAGNOdent) (Figures 3 and 4) has been shown in many laboratory studies to have high sensitivity and specificity for detecting both incipient lesions (limited to the enamel, particularly the lateral walls of the fissures) and extensive fissure caries involving the dentine, when using histology as the gold standard. Based on the work of Adrian Lussi, a DIAGNOdent score of 35 indicates deep dentine caries (grade D4) with a

specificity of 98%. Scores of 25 indicate dentine caries beyond the DEJ (Figure 5).

Its performance for extensive dentine lesions is of particular interest since the DIAGNOdent is typically employed for screening such surfaces as an adjunct to clinical examination. A recent laboratory study conducted at the University of Queensland[13] compared visual-tactile examination with conventional radiographs, digital radiographs (Sirona Sidexis) and DIAGNOdent in the detection of occlusal occult dentine caries on 320 extracted premolar teeth which did not have obvious caries or restorations. Some 302 teeth were scored as sound by the visual-tactile examination. Of these, 57 (19%) demonstrated a dentine radiolucency on conventional bite-wing films. The sensitivity and specificity values for visual-tactile examination compared with conventional radiography were 81% and 44%, respectively. In contrast, DIAGNOdent examination produced results of 82% sensitivity when compared with conventional radiography as the standard. When compared to digital radiography, the sensitivity of the visual-tactile examination was 90%, and with DIAGNOdent was 91%. Although the diagnosis of occult dentinal caries may be further enhanced by the DIAGNOdent, a combination of visual-tactile examination and either conventional or digital radiography should identify over 80% of such lesions. These conventional methods will, however, miss incipient (small) lesions, and this routine use of DIAGNOdent to assist clinical examination is worthwhile.

Figure 5. Sectioned tooth showing a lesion at the DEJ, which gave a score of 25 when examined from the occlusal surface with the DIAGNOdent.

Sealants used in the management of incipient caries

Fissure sealants applied therapeutically to early pit and fissure lesions dramatically reduce the viable bacterial flora to a level which is too low to enable the carious lesion to progress.[14] Provided the sealant material remains intact, the caries process should terminate. This makes sealants useful as a combined preventive/therapeutic treatment in the "don't know" situations where it is difficult to decide whether a small pit or fissure lesion is present or not.

The principle of "If in doubt, treat or seal" applies equally well to deciduous and permanent dentitions, and to all pitted or fissured tooth surfaces. The belief that sealants should not be used in adults was as a therapeutic measure in adults because the surfaces were at lower risk from caries was formally disproven some 20 years ago.[15]

The invasive sealant approach[16,17] is commonly employed since micro-invasive treatment of the lateral fissure walls removes organic plus aprismatic enamel and surface debris, and thereby enhances adhesion of resin materials to the occlusal enamel. Any enamel caries is removed using a miniature high speed diamond bur, air abrasion particle beam or erbium laser, with care being taken to ensure that the preparation is conservative and remains within enamel. The enamel is then etched and a sealant placed. For more extensive lesions showing involvement of the DEJ, a preventive resin restoration (PRR) is undertaken.

The advantages of invasive sealants and PRR are:

1. There is minimal removal of tooth structure, hence greater tooth strength.
2. There is no marginal leakage, with a reduced risk of recurrent caries.
3. Local anaesthetic is not normally required.
4. The restoration can be completed in one visit and polishing is not required.
5. Caries in adjacent pits and fissures is prevented without fissure removal.
6. Pleasing aesthetics are obtained.
7. The restorations are cost-effective and can be easily repaired.

With filled resins, precise occlusal adjustment must be undertaken, whereas some latitude exists with unfilled sealants which will wear until in satisfactory occlusion. The fissure morphology and the occlusion (e.g. load bearing area) will largely dictate the choice between filled and unfilled products. Strict adherence to moisture control must be observed. Saliva control can normally be achieved by the correct placement of a sufficient number of cotton rolls. Gaining adequate control of the oral environment at the time of placement is critical for long term success of resins, when used for PRR or as plain sealants.[18]

In summary, to achieve maximum benefit, sealants should:

- Be used for targeted prevention in high-risk children and young adults.
- Be applied to teeth such as mandibular molars that are likely to develop caries.
- Be used in conjunction with other preventive measures.
- Employ contemporary resin materials (second or third generation resins), or glass ionomers with appropriate viscosity and surface wetting properties.
- Be placed by dental auxiliaries (dental therapists or dental hygienists) to reduce their overall cost.
- Be monitored over time and re-applied as needed.

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